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Extracorporeal Shock Wave Lithotripsy 25 Years Later: Complications and Their Prevention

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Abstract

Objective: We review the pathophysiology and possible prevention measures of complications after extracorporeal shock wave lithotripsy (ESWL).
Methods: A literature search was performed with the Medline database on ESWL between 1980 and 2004.
Results: ESWL application has been intuitively connected to complications. These are related mostly to residual stone fragments, infections, and effects on tissues such as urinary, gastrointestinal, cardiovascular, genital, and reproductive systems. Recognition of ESWL limitations, use of alternative therapies, correction of pre-existing renal or systemic disease, treatment of urinary tract infection, use of prophylactic antibiotics, and improvement of ESWL efficacy are the most important measures of prevention. Decrease of shock wave number, rate and energy, use of two shock-wave tubes simultaneously, and delivery of two shock waves at carefully timed close intervals improve ESWL efficacy and safety.
Conclusion: ESWL is a safe method to treat stones when proper indications are followed. The need for well-designed prospective randomised trials on aetiology and prevention of its complications arises through the literature review.

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1. Introduction

Since its first presentation in West Germany in the early1980s [1], extracorporeal shock wave lithotripsy (ESWL) has revolutionized the treatment of urinary lithiasis. ESWL has gained rapid acceptance worldwide because of its ease of use, noninvasive nature, high efficacy in treating kidney and ureteral stones, and wide availability of lithotriptors. ESWL acts via a number of mechanical and dynamic forces on stones such as cavitation, shear, and spalling [2]. The most important force is thought to

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Table 1 – Complications after ESWL for urinary stones

Immediate	Delayed
Related to stone fragments	Renal Function?
Infectious	Hypertension?
Tissue effects	Fertility?
• Renal (haematoma, haemorrhage)	
• Cardiovascular	
• Gastrointestinal	
• Genital system	
• Foetus	

be cavitation [2]. The destructive forces generated when the cavitation bubbles collapse are responsible for the ultimate stone fragmentation. However, they can also cause trauma to thin-walled vessels in the kidneys and adjacent tissues [3], which result in haemorrhage, release of cytokines/inflammatory cellular mediators, and infiltration of tissue by inflammatory response cells. These may lead to short-term complications and to formation of scar and possible chronic loss of tissue function (Table 1).

In this review we present an overview of the post-ESWL complications, their potential mechanisms and predisposing factors, and various ways to prevent them. A thorough Medline search was performed to review various types of papers such as clinical trials, randomised controlled trials, reviews, meta-analysis, editorials, and letters to the editor. Combinations of the following keywords were used: ESWL; complications; stone fragmentation; failure; residual stones; obstruction; steinstrasse; infection; renal anatomy; renal function; hypertension; vascular; cardiac; gastrointestinal; children; fertility; and pregnancy. We reviewed 3,937 abstracts and read 220 papers in full. Ninety-three of these are sited in the reference list.

2. Complications related to stone fragments

Incomplete fragmentation, residual stone fragments, steinstrasse, and obstruction are among the problems urologists confront when ESWL fails to completely fragment the stone treated (Table 2).

Growth of residual fragments <4 mm has been documented in 21%–59% of patients who underwent ESWL [4,5]. Streem et al demonstrated a 43% risk of having a symptomatic episode or needing an intervention, or both, after a mean 26-month follow-up in patients with residual calculi $\leq$4 mm [6]. With increasing renal persistence of residual fragments, the probability of stone clearance seems to decrease [5]. However, the location of residual fragments does not significantly influence stone clearance rate [5].

Table 2 – Complications of ESWL related to stone fragments

Possible predisposing factors	Possible prevention measures
Hard stones	Alternative therapy for hard and large stones (PCNL, sandwich therapy)
Large stones	Stenting when treating large stones
Lower pole stones	Improve ESWL efficacy
Increased number of stones	
Impaired renal anatomy	
Increased shock wave rate	
Decreased shock wave energy	

2.1. *Predisposing factors*

Predisposing factors to ESWL failure are stone composition, size, location, and number, as well as renal morphology and shock wave rate and energy [7,8]. The fragmentation rate of cystine and calcium oxalate monohydrate stones is low [9]. The ESWL success rate decreases as the stone size increases. Chaussy et al. in 1984 reported a stone-free rate of 91% for stones less than 2 cm [1]; stone-free rates for stones 2–3 cm are 50%–70% and decrease further for staghorn stones [10]. The success rate of ESWL is lower for lower pole calculi than for other stone locations [11]. Lingeman et al. reported stone-free rates of 29% for patients with lower pole calculi of 11–20 mm and 20% for those with calculi >20 mm [11]. The presence of multiple stones has also been related to a higher recurrence of stones after ESWL [1–4]. ESWL is effective for stones in the ureter, although less effective than initial treatment than ureteroscopy [12]. The stone-free rate seems to be related to stone location. For proximal ureteral stones there has been a higher success rate (65%–81%) than for lower ureteral stones (58%–67%). ESWL should be considered as initial treatment in cases such as stones <10 mm [12].

Shock wave rate affects stone fragmentation in vitro and in vivo, improved ESWL efficiency occurring at slower rates [13]. Similarly, progressive increase in lithotripter output voltage improves stone comminution in vitro [14]. However, only two clinical studies [15,16] have addressed the effect of varying shock wave rate on the efficiency of stone fragmentation. The authors confirmed the positive effect of lowering shock wave rates in treating ureteral stones, which indicates the necessity of large randomised clinical trials.

New generation types of the same lithotriptor design or lithotriptors of different design show variable fragmentation ability. Portis et al. [17]